

Electrolyte and Electrode Passivation for Thin Film Batteries

W. C. West, J. Whitacre, B. V. Ratnakumar,
E. Brandon, J. O. Blosiu and S. Surampudi
*Electrochemical Technologies Group
Jet Propulsion Laboratory
California Institute of Technology
Pasadena CA 91109*

Selection of materials for Li thin film batteries involve similar concerns associated with conventional Li batteries. However, the preparation techniques used to prepare thin film batteries offer distinct advantages over conventional battery fabrication by allowing for the engineering of cells with multi-layer components. For example, a thin film electrolyte structure may be fabricated with a high ionic conductivity material coated with a material with high stability versus Li.¹ The development of films that can provide stability at anode and cathode potentials enables the use of many previously unusable electrolyte materials with poor chemical or electrochemical stability, and eases the developmental constraints on novel electrolytes.

Thin films of sputtered Li_2CO_3 are currently being examined as passivation layers for thin film batteries due to the advantages compared to other passivation layers, including:

- Excellent passivation against electrolyte reaction at the anode²
- Excellent oxidative stability at high voltage as evidenced by the oxidative stability of carbonate-based liquid electrolytes up to 4.8V³
- Good stability against humidity in air⁴

The latter advantage is quite important in practical terms, since air sensitive components of a thin film battery such as the Li anode can be passivated with Li_2CO_3 and effectively moved between processing tools in ambient air.

Impedance spectroscopy studies indicate that Li_2CO_3 films sandwiched between Mo electrodes have identical features compared with other solid electrolyte films such as Lipon,⁵ and thus can be modeled using the same equivalent circuit, as shown in Figure 1. The room temperature conductivity of the Li_2CO_3 films is rather poor, approximately $5 \times 10^{-9} \text{ S/cm}$. However, the conductivity can be fit to an Arrhenius activation, with a relatively low activation energy of approximately 0.35 eV, shown in Figure 2. Given the low conductivity of the films, Li_2CO_3 cannot serve as a bulk electrolyte film, but is more suited as a thin passivating film.

From this study, multi-layer electrolytes employing Li_2CO_3 passivation layers will be examined with the intent of demonstrating long calendar life, high capacity, high voltage thin film batteries.

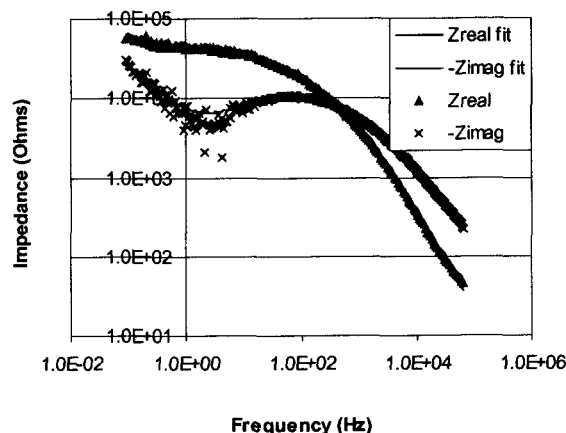


Fig. 1 Bode plot of unpassivated $\text{Mo}[\text{Li}_2\text{CO}_3]\text{Mo}$ test structures at room temperature, fit to solid electrolyte model.⁵

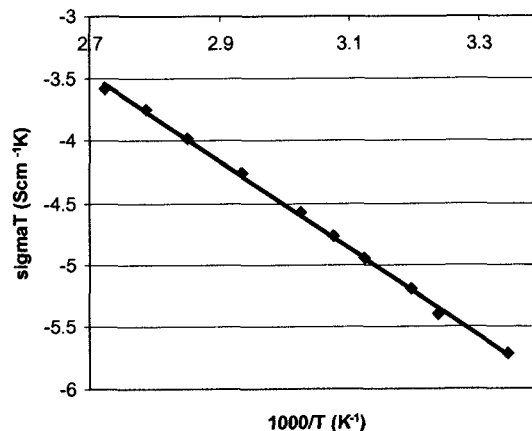


Fig. 2. Arrhenius plot of unpassivated $\text{Mo}[\text{Li}_2\text{CO}_3]\text{Mo}$ test structures.

Acknowledgments

The work described here was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.

References

- ¹S. D. Jones and J. R. Akridge, *Solid State Ionics*, **69**, 357 (1994).
- ²H. Gan and E. S. Takeuchi, *J. Power Sources*, **62**, 45 (1996).
- ³D. Guyomard and J. -M. Tarason, *J. Power Sources*, **54**, 92 (1995).
- ⁴J. Mizusaki, H. Tagawa, K. Saito, K. Uchida, and M. Tezuka, *Solid State Ionics*, **53**, 791 (1992).